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Extraterrestrial High Energy Neutrino Fluxes

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F. W. Stecker

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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F. W. Stecker

NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract

Using the most recent cosmic ray spectra up to 2×10^{20} eV, production spectra of high energy ν's from cosmic ray interactions with interstellar gas and extragalactic interactions of ultrahigh energy cosmic rays with 3K universal background photons are presented and discussed. Estimates of the fluxes from cosmic diffuse sources and the "nearby" quasar 3C273 are made using the generic relationship between secondary ν's and γ's and using recent γ-ray satellite data. These γ-ray data provide important upper limits on cosmological ν's. Quantitative estimates of the observability of high energy ν's from the inner galaxy and 3C273 above atmospheric background for a DUMAND type detector are discussed in the context of the Weinberg-Salam model with $\sin^2\theta_W = 0.2$ and including the atmospheric background from the decay of charmed mesons. Constraints on cosmological high energy neutrino production models are also discussed. It appears that important high energy neutrino astronomy may be possible with DUMAND, but very long observing times are required.

1. Introduction

There have been a number of recent papers estimating high-energy neutrino fluxes and spectra from various astrophysical processes[1-6]. In this work, I reexamine the problem by 1) presenting the results of a detailed calculation of galactic ν-production in cosmic-ray interactions with interstellar gas and extragalactic ν-production by interactions of ultrahigh energy cosmic rays with the 3K universal background radiation, 2) using these results together with present γ-ray observations to predict neutrino fluxes and event rates, and 3) discussing the problem of observing extraterrestrial ν fluxes above the atmospheric background.

2. Production Rates

The first basic production process for high energy cosmic neutrinos is the decay of charged pions produced in cosmic ray interactions with interstellar gas, primarily pp interactions. This process will henceforth be referred to as "pp", although the effects of αp pHe and αHe interactions are included in the calculation. The second process involves the photoproduction of π-mesons by interaction of ultrahigh energy cosmic rays with the 3K universal microwave background radiation (henceforth referred to as γp) and subsequent meson decay. Both of these types of interactions involve the accompanying production of π° mesons and their decay into cosmic γ-rays. Thus, the production rates of cosmic γ-rays and neutrinos are generically linked.

2.1 pp Neutrino Production

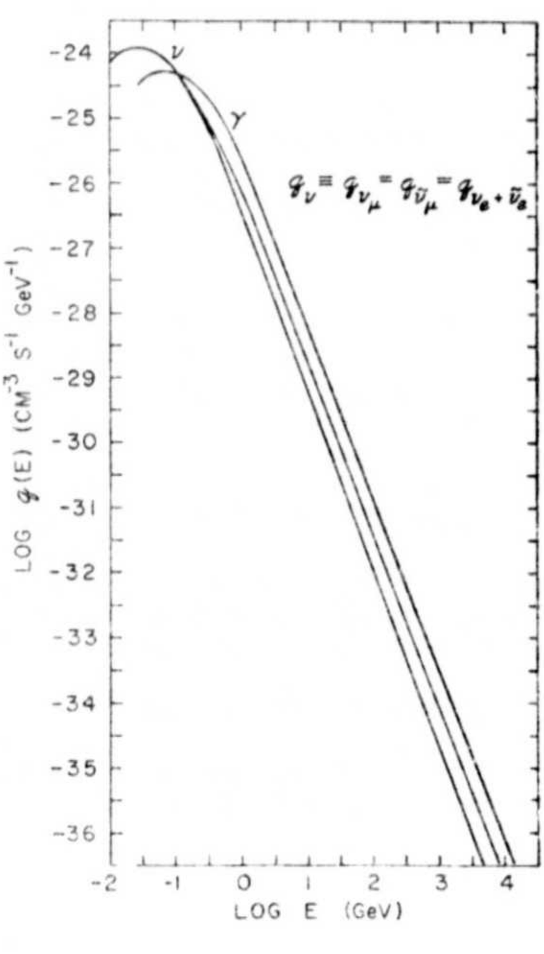
A detailed discussion of the kinematics of the production and decay of secondary particles produced in "pp" interactions may be found in

Reference 7. Details of the γp process have also been previously given.[8] The γ-ray production spectrum in γp interactions has been calculated by several workers.[2,9,10]

In the present paper, the "pp" neutrino production spectrum was calculated for pp interactions up to 30 GeV by methods previously employed.[7,11] At higher energies, scaling was assumed to hold. At these energies, the parameters of Ganguli and Sreekantan[12] were adopted for the rapidity distribution of charged pions. These authors have calculated γ-ray spectra which are in good agreement with those of the present author[13] for γ-ray energies $\leqslant$ 10 GeV. At higher energies, the assumption of scaling gives larger fluxes and a flatter spectrum than those calculated using an "isobar + fireball" model in "pre-scaling days".[7] It should be noted that the isobar + fireball (I-F) model is equivalent to a "leading-pion" model at high energies, since the isobar carries off $\sim$ 50% of the energy and decays into a "leading pion". Both scaling and the I-F models produce a secondary spectrum which has the same spectral index as the primary spectrum in the high-energy limit.

The results of the "pp" production spectrum calculation are shown in Fig. 1. The two neutrino production spectra are given for an inter-

Fig. 1 - Differential production spectra of neutrinos and γ-rays from the decay of pions produced by interactions of cosmic-rays in our galactic neighborhood with interstellar gas having a mean hydrogen density of 1 atom per cm^3. The γ-ray curve and the upper neutrino curve are calculated for cosmic rays having a spectral index of 2.67 between 10 and $3x10^6$ GeV; the lower neutrino curve is for a cosmic ray spectrum with index 2.75. The spread in the curve is indicative of the uncertainty in such calculations.



stellar hydrogen density of $1 cm^{-3}$ so that it is really a production rate per hydrogen atom. The upper neutrino curve and the γ-ray production spectrum shown in the figure are calculated using a primary cosmic ray spectrum $I_p(E) = 2.35\ E^{-2.67} cm^{-2} s^{-1} sr^{-1} GeV^{-1}$ for $E_p > 10$ GeV and the lower curve is obtained for a primary spectrum $I_p(E_p) = 2.0\ E^{-2.75} cm^{-2} s^{-1} sr^{-1} GeV^{-1}$ (Ref. 14). (Most recently, Goodman, et al.[15] have reported a primary proton spectrum of $1.5\ E^{-2.71\pm 0.06} cm^{-2} s^{-1} sr^{-1} GeV^{-1}$ for $10^6 \geq E \geq 10^5$ GeV, consistent with the lower value given in Ref. 14.) The γ-ray spectrum is for <u>all</u> γ-rays from π^0-decay; the ν-spectrum is for the ν_μ component. Since each pion decay results in one ν_μ, one $\tilde{\nu}_\mu$ and one $\nu_e(\tilde{\nu}_e)$, all of roughly the same energy, the total number of ν's produced (although of four different types) is a factor of 3 higher than that shown for ν_μ's. in this regard, it should be kept in mind that the cross section ratios given in Table 1 apply.

Table 1. νN Cross Section Ratios

Ratio	Experimental Value (Refs. 54,55)	Theoretical Value
$\sigma_{\nu_e N}/\sigma_{\nu_\mu N}$	1.26 ± 0.23	1
$\sigma_{\tilde{\nu}_e N}/\sigma_{\tilde{\nu}_\mu N}$	1.32 ± 0.32	1
$\sigma_{\tilde{\nu}_\mu N}/\sigma_{\nu_e N}$	0.40 ± 0.12	$\sim 1/3$*
$\sigma_{\tilde{\nu}_e N}/\sigma_{\nu_e N}$	0.38 ± 0.02	$\sim 1/3$*

*valence quarks dominant

Figure 2 shows the integral galactic "pp" neutrino production spectrum.

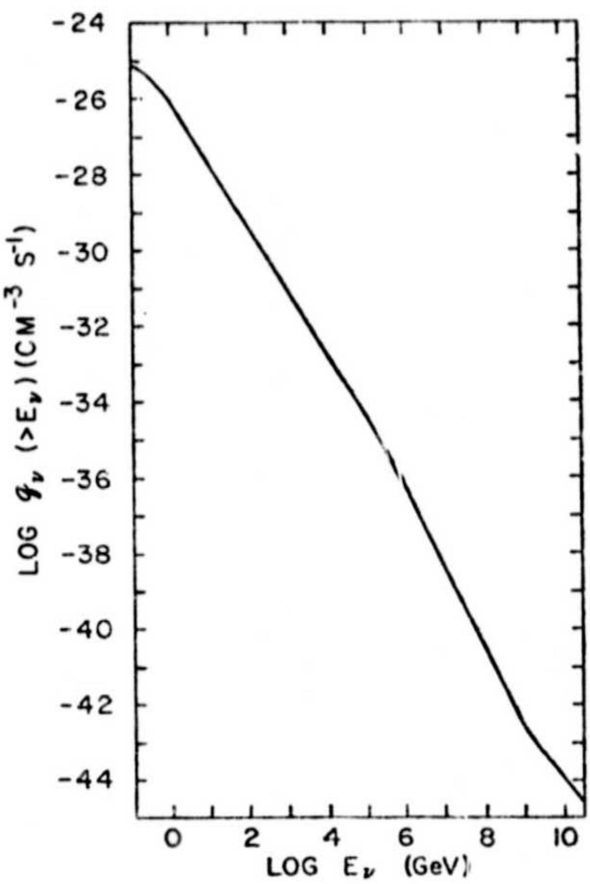


Fig. 2 - The integral ν-production spectrum obtained from the upper neutrino curve in Fig. 1. The high energy cosmic ray spectrum used is from a recent analysis of Hillas (private communication).

2.2 pγ Neutrino Production

The production rate for γp interactions has been calculated using the method of Ref. 9. As an example of the range of uncertainty, two different primary spectra were used, i.e. $I_p(E_p) = 6.4 \times 10^{-31} (E_p/10^{11})^{-2.8} cm^{-2} s^{-1} sr^{-1} GeV^{-1}$ (Ref.16) and

$I_p(E_p) = 2.4\times10^{-31}(E_p/10^{11})^{-3.24}\mathrm{cm^{-2}s^{-1}sr^{-1}GeV^{-1}}$ (Ref. 17). The latest analysis of the ultrahigh energy air-shower data (Hillas, private communication) gives $I_p(E_p) \simeq 4\times10^{-31}(E_p/10^{11})^{-3}\mathrm{cm^{-2}s^{-1}sr^{-1}GeV^{-1}}$ in the energy range $10^{8}\leqslant E_p\leqslant 10^{10}$ GeV with indications of a flattening to $I_p(E_p) \simeq 2\times10^{-30}(E_p/10^{11})^{-2.3}$ in the energy range $10^{10}\leqslant E_p\leqslant 10^{11}$GeV. The results of the γp calculation are shown in Figure 3 for the two spectra chosen. The right-hand scale of Figure 3 also shows the diffuse background flux from this process obtained by multiplying by the factor $c/(4\pi H_o)$ where H_o, the Hubble constant, is taken to be $50\mathrm{km\ s^{-1}Mpc^{-1}}$. This flux, which is also shown in the subsequent figures, only holds if the ultrahigh energy primary spectrum is universal, an assumption which is contradicted by the lack of an observed high energy cutoff in the spectrum[8,18-20]. Thus the fluxes given may be overestimated and may actually be upper limits.

3. Diffuse Cosmic Neutrino Fluxes

Figures 4 and 5 show the differential and integral $\nu_\mu+\tilde{\nu}_\mu$ fluxes from various sources (the corresponding flux of electron-neutrinos and antineutrinos is lower by a factor of two.) In Figure 4, the cross-hatched region marked γp is obtained from the curves shown in Figure 3. The hatched region marked pp(G.C. $|b|\leq10^o$) is for galactic ν-production coming from the galactic central region defined by galactic longitude $330^o\leq\ell\leq40^o$ and latitude $|b|\leq10^o$. The dashed line is the flux computed using the isobar-fireball (I-F) model[7], which is probably too low. The lines bounding the hatched region are obtained using the two "pp" production spectra shown in Figure 1. All galactic "pp" curves are normalized by assuming that ½ of the galactic γ-radiation above 100 MeV observed by SAS-2[21] is from π^0-decay and by relating the γ-ray and ν-production using the results given in Figure 1. Spectral measurements indicate that $\sim$ 50% of the galactic γ-rays observed above 100 MeV are most probably from cosmic-ray electron bremsstrahlung with no associated ν-production. The curve marked PCR (UL) is an upper limit on the ν-flux from primordial (or "cosmological") cosmic-ray interactions obtained under the assumption that the extragalactic γ-ray background (8×10^{-6} $\mathrm{cm^{-2}s^{-1}sr^{-1}}$ above 100 MeV with an E^{-3} power law spectrum) is from interactions of cosmic-rays at high redshifts.[22] A detailed comparison of the calculated and observed spectra[23-25] indicates that the γ-ray background is most probably not from PCRs so that the curve shown is an upper limit. Note that this upper limit is many orders of magnitude below the absolute cosmological neutrino upper limit given in Reference 3 (see Section 7).

The integral fluxes in Figure 5 show galactic "pp" muon-neutrino and antineutrino fluxes for the central region $330^o\leq\ell\leq40^o$ (GC) for $|b|\leq2^o$ and $|b|=10^o$, the anticenter region (AC) for $|b|\leq2^o$ and the region of the galactic poles (GP). All of these spectra were normalized using the SAS-2 γ-ray data[21] except for the GP curve which was obtained from Fig. 2 using a mean galactic path length of hydrogen gas $\langle nL\rangle = 3\times10^{20}\mathrm{cm^{-2}}$. The atmospheric $\nu_\mu+\tilde{\nu}_\mu$ flux shown in Fig. 5 is from Allkofer et al.[26] who used the atmospheric muon data to derive their fluxes. The curve marked "other galaxies" is obtained by assuming a density of normal galaxies of $3\times10^{-76}\mathrm{cm^{-3}}$ (Ref. 27), assuming that they have the same γ-ray luminosity as our galaxy which is assumed to radiate ½ of its γ-ray flux from π^0-decay. Note that since the predicted γ-ray spectrum

from normal galaxies is considerably flatter than the observed extragalactic background, so that the limit on the γ-ray flux from other galaxies due to π^0-decay is probably $\sim 2\times10^{-6}$ $cm^{-2}s^{-1}sr^{-1}$ above 100 MeV, the ν-background from $\pi^{\pm}$-decay cannot be significantly higher than the curve marked "other galaxies".

Figure 6 shows the latitude distribution of $\nu_\mu+\bar{\nu}_\mu$ calculated for energies above 1 TeV by extrapolation from the SAS-2 γ-ray data.

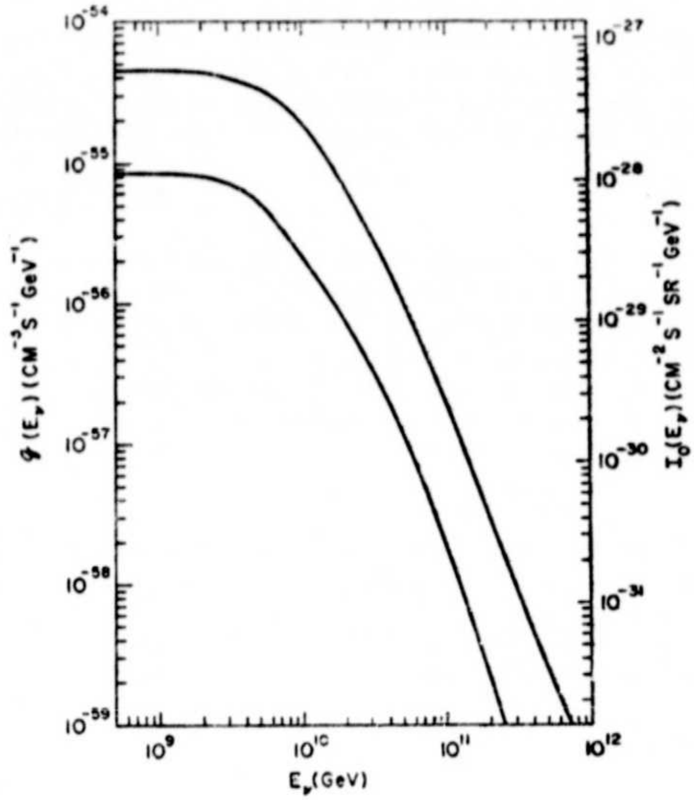


Fig. 3 - Calculated differential neutrino production spectra and background fluxes from photopion production by ultrahigh energy cosmic rays interacting with the 3K universal microwave background radiation.

4. Prompt Atmospheric Neutrinos

A new source of "prompt" neutrinos, possibly from the decay of charmed mesons, has been found in recent beam dump experiments at CERN[28-30]. The ratio of the production rates of these neutrinos to π-production is $R \gtrsim 10^{4}$. A summary of the present data on charmed meson production is given in Reference 31. The importance of prompt neutrino production in the atmosphere at high energies has been discussed by several workers.[3,32,33]

Figures 7 and 8 show the estimated fluxes of prompt (PR) muon and electron neutrinos for $R \simeq 10^{-4}$ and $R = 10^{-3}$ (an R value between these two numbers appears most likely at this writing) together with the horizontal and vertical fluxes of atmospheric neutrinos[25] and our estimates of the neutrino flux from the central part of the Galaxy. It can be seen that prompt neutrinos from the atmosphere have a spectrum and intensity which may mimic those of galactic neutrinos. Furthermore, even with directional information, a "large" background of prompt neutrinos may make it difficult to pick out a galactic "signal".

The neutrino flux from the inner Galaxy is expected to be confined

mainly to a narrow band in the sky (see Fig. 6) which, in principle, can be picked out above the atmospheric background[34] with a detector such as the proposed DUMAND system with an angular resolution of better than $1/2^{\circ}$ above 10^{3} GeV energy.[35] (see section 6.1).

5. Event Rates

The νN cross section rises linearly with E_{ν} and is $\sim 0.7\times10^{-38}E_{\nu}\mathrm{cm}^2$ at accelerator energies.[36] The $\bar{\nu}N$ cross sections are $\sim 1/3$-0.4 of this value (see Table 1), although there is now evidence of an increase in this ratio to ~ 0.6 at $E_{\nu} \sim 100$ GeV[37], possibly due to a new flavor b-quark with $m_b \sim 5$ GeV.[38] Owing to scaling violations and quantum chromodynamics, this ratio may approach unity at $E_{\nu} \gtrsim 10^{6}$ GeV.[39] Above a critical energy

$$E_{\nu}^{c} \sim M_W^{2}/2M_p, \tag{1}$$

where M_W is the mass of the intermediate vector boson and M_p is the proton mass, the energy dependence of the cross section levels off to a logarithmic one.[40] In the unified gauge theory of Weinberg and Salam, $M_W = 37.3 \csc \theta_W$, where θ_W is the mixing angle parameter expressing the relationship between the neutral current and electromagnetic coupling constants.[41] The best experimentally determined value at present is $\sin^2\theta_W \simeq 0.2$ (Ref. 42) giving $M_W \simeq 84$ GeV. The resulting νN cross section as a function of E_{ν} is shown in Fig. 9.

Using the νN cross section from Fig. 6 for M_W = 84 GeV (solid line) and a strictly linear cross section ($M_W = \infty$ dashed line) together with the calculated cosmic ν-fluxes, expected event rates for ν_{μ}'s falling on a detector with an effective mass of 10^{10} tons of seawater as proposed for the DUMAND experiment were calculated and are given in Fig. 10. The dotted line marks the level corresponding to 100 events/yr. The upper "pp" curve is for the flux from the galactic central region using the production spectrum of Fig. 2, which is derived from the upper ν-curve of Fig. 1. The curve marked $\langle pp \rangle_{GAL}$ is for the galactic "pp" neutrinos averaged over 4π sr. Thus, on the average, one would expect an event rate of ~ 40 yr^{-1} from galactic ν_{μ}'s of energy > 10 TeV. If ultra-

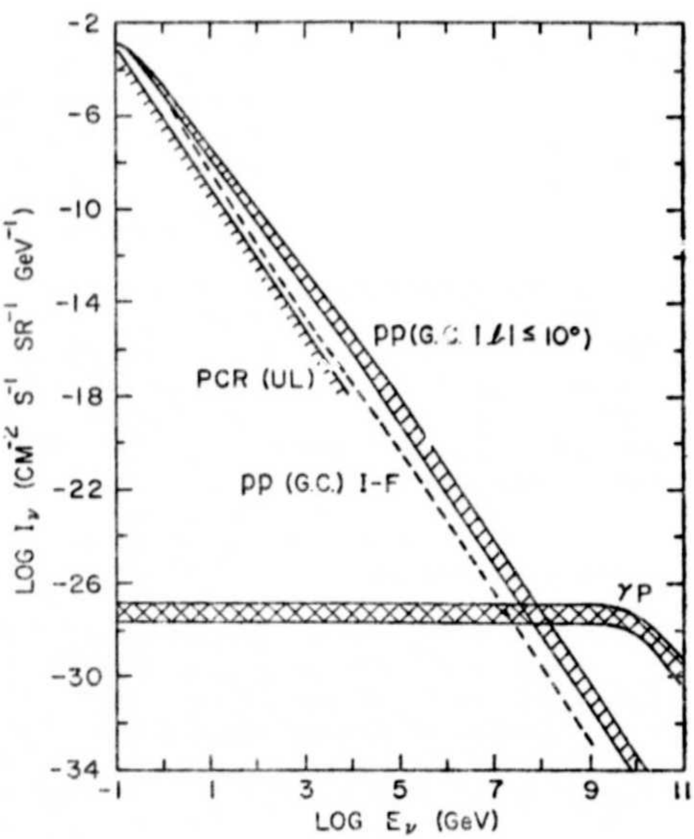


Fig. 4 - Differential background ν-fluxes.

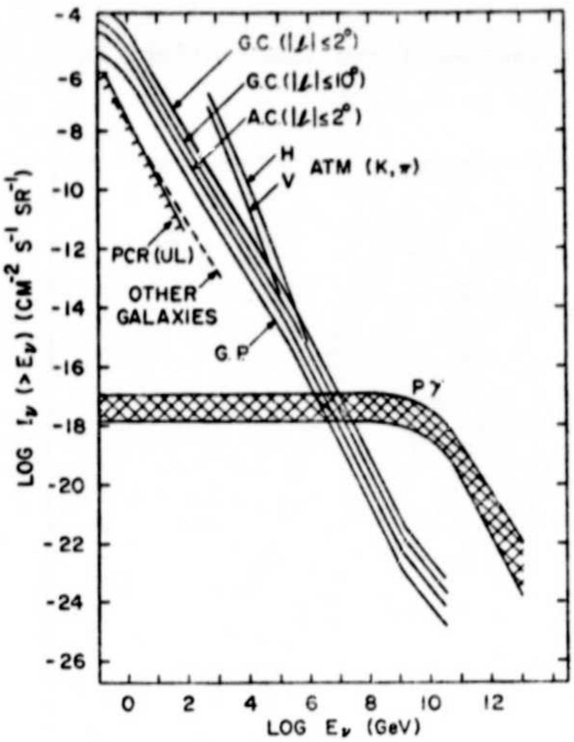


Fig. 5 - Integral $\nu_\mu+\tilde{\nu}_\mu$ fluxes from cosmic sources and atmospheric π and K decay.

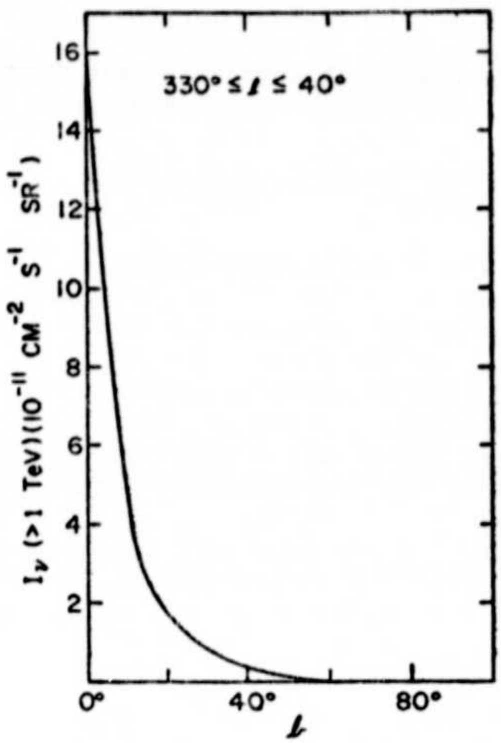


Fig. 6 - The galactic latitude distribution of neutrinos with energy above 1 TeV in the direction of the inner galaxy.

high energy cosmic rays are universal (not likely) and the νN cross section rises linearly up to $\sim 10^9$ GeV ($M_W \gtrsim 5\times10^4$ GeV, again not likely) this rate could again be reached for $E_\nu > 10^9$ GeV from γp interactions except for the fact that if $n\sigma_{\nu N}$ becomes greater than the effective geometric area of the detector, A, the detector becomes area limited and the event rate is $I_\nu A\ s^{-1} sr^{-1}$ (see Fig. 10). (However, in this case, the ocean above a DUMAND type detector would be opaque to ν's.) It is more likely, however, that at energies high enough to see steady diffuse fluxes of cosmic neutrinos with a 10^{10} ton detector above the atmospheric background, the event rates will be very low. The resulting statistics will make it hard to see galactic neutrinos above an isotropic background of prompt neutrinos (see section 6.1).

6. Observability of Extraterrestrial Sources

The large fluxes of high energy neutrinos produced in the atmosphere as the result of the decay of secondary mesons arising in cosmic-ray interactions with atmospheric nuclei provide a significant background which, although useful from the point of view of neutrino physics, provides constraints on conducting neutrino astronomy observations. Below ~ 10 TeV, neutrinos from π and K decay create a noisy background problem which, because of the softness of their spectrum, gets worse at lower energies. At energies above ~ 10 TeV, the prompt neutrinos from D-decay take one more significance because of their harder spectrum which mimics the galactic spectrum (see section 4). One must therefore consider the

observability of various cosmic neutrino sources above fluctuations in this noisy atmospheric background.

6.1 Observability of the Inner Galaxy

The observability criterion adopted for quantitative estimates is the number of standard deviations a cosmic source signal would provide above atmospheric fluctuations. Based on the results given in the previous section, we find that the number of galactic neutrinos ($\nu_\mu + \nu_{\bar{\mu}}$) observed in one year at $E \geq 10$ TeV in a 10^{10} ton DUMAND detector is calculated to be 45 if one used a primary cosmic ray spectrum $dJ/dE \propto E^{-2.67}$. However, adopting the steeper primary spectrum obtained in more recent work[14,15] a more conservative event rate is obtained. The primary spectrum given in Ref. 14, which is consistent with the data in Ref.'s 15 and 26, will be adopted here, yielding a galactic event rate of ~ 18/yr above 10 TeV. At 1 TeV, the event rate is ~ 16 times higher.

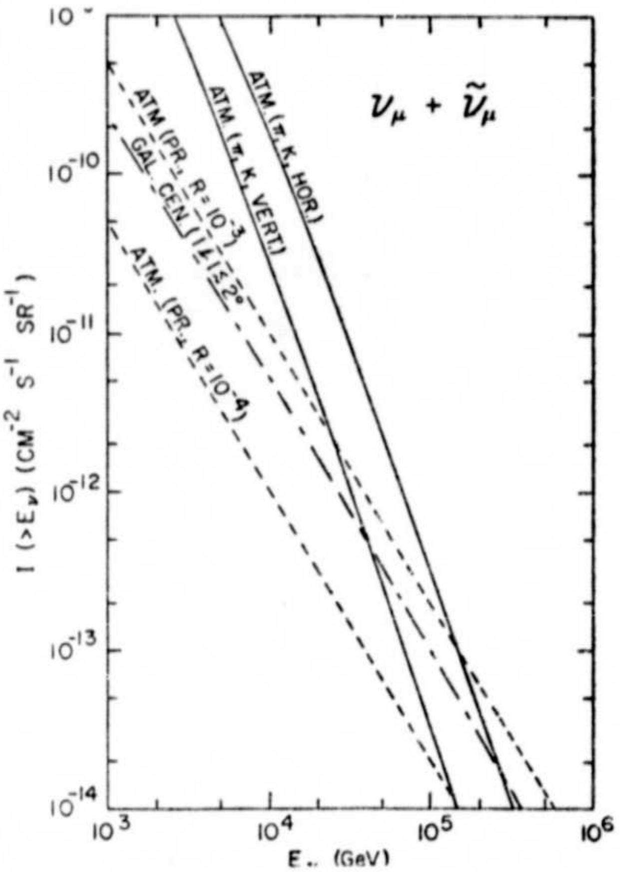


Fig. 7 - Fluxes of atmospheric muon-neutrinos from π and K decay and from prompt decay as compared with the predicted diffuse flux from the inner galaxy.

About 45% of the expected galactic events come from a galactic central region $\pm 8°$ in latitude and $\pm 50°$ in longitude. The prompt atmospheric neutrino fluxes for $R = 10^{-4}$ and $R = 10^{-3}$ are given in Figure 7. The atmospheric π and K decay fluxes are given in Ref. 26. The mean atmospheric neutrino flux from π and K decay is ~ 0.5 of the horizontal flux at 1 TeV and ~ 0.3 at 10 TeV.[43]

The event rates for a 10^{10} ton detector as given in Ref. 34 are shown in Table 2. It can be seen that the inner region of the galaxy may be detectable above atmospheric background fluctuations with observing runs of 4 years or longer.

6.2 Observability of the Nearby Quasar 3C273

In considering neutrino astronomy of extragalactic point sources, the quasar 3C273 provides an excellent subject for consideration because of its closeness and prominance among quasars and because it is the only known extragalactic source of 100 MeV γ-rays. Thus, if the γ-radiation from 3C273 is the result of meson production in cosmic-ray interactions

Table 2. Observability of Galactic Central Region

	Energy (TeV)	N_{Prompt}	Number of Atmospheric Neutrino Events/yr. $N_{\pi K}$	$(N_{pr}+N_{\pi K})^{-1/2}$	Number of ν's from G.C./yr.	σ's of G.C. Events Above Atm. Bkgd. (4 yr)
		$(R=10^{-3})$				
$\nu_\mu+\bar{\nu}_\mu$	≥ 1	380	17,600	130	130	2.0
	≥ 10	23	120	12	8	1.4
$\nu_e+\bar{\nu}_e$	≥ 1	380	790	34	65	3.8
	≥ 10	23	4	5.2	4	1.5
		$(R=10^{-4})$				
$\nu_\mu+\bar{\nu}_\mu$	≥ 1	38	17,600	130	130	2.0
	≥ 10	2.3	120	11	8	1.4
$\nu_e+\bar{\nu}_e$	≥ 1	38	790	29	65	4.5
	≥ 10	2.3	4	2.5	4	3.2

In the source, either through π^o-decay or the bremsstrahlung of electrons from $\pi^\pm$ decay, the 100 MeV neutrino flux from 3C273 may be comparable to the $\sim 6\times10^{-7}$ $cm^{-2}s^{-1}$ γ-ray flux observed by the COS-B satellite[44] for this source.

Taking the resolution element for neutrinos with E>1 TeV from DUMAND to be $\Omega_R = 3\times10^{-4}sr$[35], the atmospheric neutrino event rate in Ω_R is expected to be $\sim$11/yr above 1 TeV. Thus, a 3σ signal, certainly the absolute minimum for observability of a point source, would be $\sim$10/yr. For a source with a differential energy spectrum $\propto E^{-2.7}$, this would correspond to a $\geq$1 TeV neutrino flux of $\sim 6\times10^{-12}$ $cm^{-2}s^{-1}$. If the integral ν-spectrum from 3C273 follows an $E^{-1.7}$ power law from a value of $6\times10^{-7}cm^{-2}s^{-1}$ at 100 MeV, the resultant flux above 1 TeV would be $\sim 10^{-12}cm^{-2}s^{-1}$, a factor of 60 below the level of detectability. Indeed, the integral spectrum would have to be flatter than $E^{-1.25}$ for detectability, which seems unlikely since the photon spectrum appears to steepen between the x-ray and γ-ray range[45]. The case for detectability of other steady extragalactic sources whose 100 MeV

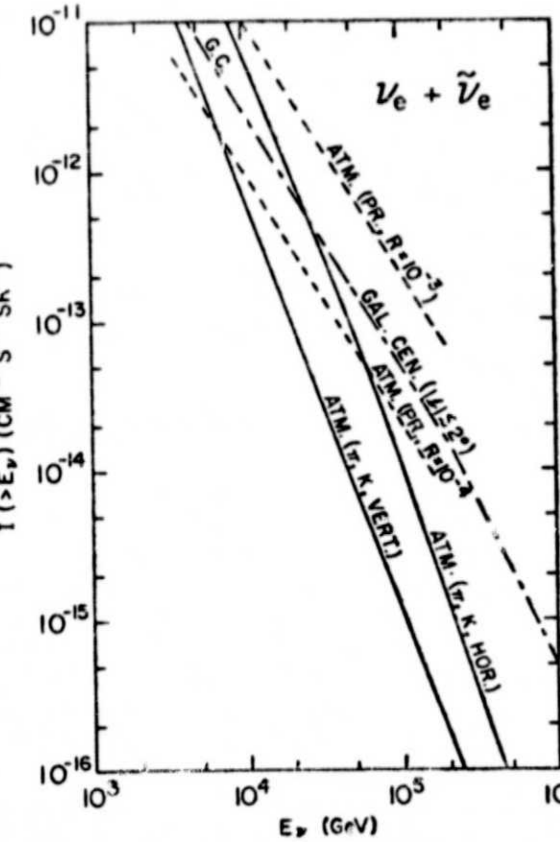


Fig. 8 - Fluxes of atmospheric electron-neutrinos from π and K decay and from prompt decay as compared with the diffuse flux from the inner galaxy.

γ-ray flux remains below present satellite detectability seems even more hopeless with one possible loophole. It is possible that cosmic rays could be produced in the core regions of quasars, there producing ν's while the γ-rays are absorbed in optically thick regions. In that case, the producing regions must be much smaller than the $\leqslant 0.1$ pc size of the x-ray producing region since the column density in the x-ray producing regions is $< 4.5\times10^{21}$ cm^{-2} at the 90% confidence level[46)] less than 4 orders of magnitude below the γ-ray mean-free-path. It also appears that the γ-ray emission from quasars is more likely electromagnetic in origin[47,48)] and therefore unconnected to ν-production. It would therefore be of extraordinary interest if neutrinos from 3C273 were detected, as it would reveal entirely new information about the fundamental nature of quasars. But observability is uncertain at best in terms of present theoretical ideas.

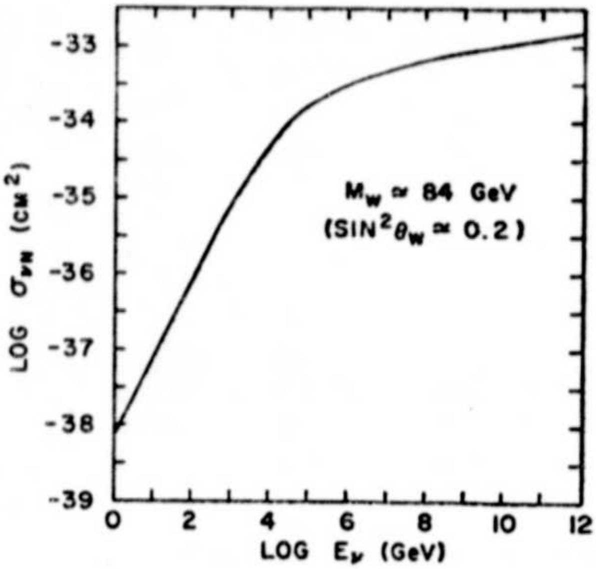


Fig. 9 - Cross section for νN interactions assuming an intermediate vector boson mass M_W = 84 GeV.

7. Cosmological Neutrino Background

Following a suggestion[49)] that a high-redshift cosmological origin of the high energy cosmic radiation could explain the steepening of its spectrum above $\sim 10^6$ GeV, a cascade origin of the cosmic γ-ray background radiation was also suggested[50)], followed by suggestions that such a burst of cosmic ray production in the distant past would result in copious neutrino fluxes[51)]. It should, however, be noted that photopion production of neutrinos in an early intergalactic (or pregalactic) medium is limited by observational constraints on the associated γ-ray background radiation[7)]. These constraints therefore call into question burst production or "bright phase" models. The "pp" limit from the γ-ray observations is shown in Fig. 5 marked PCR(UL) (see section 3). The pγ limit is not related to the x-ray background as previously suggested[51)] because the x-ray background cannot be related to photopion production since the shape of the γ-ray background has the form $\propto E^{-3}$ above 10 MeV[24)] whereas the photopion model would give a spectrum of the form [50)] $\propto E^{-2}$. Furthermore the model on which the high-redshift calculations are based implies a γ-ray background flux above that observed unless the mean intergalactic gas density at present is $\leqslant 10^{-10}$ cm^{-3} (based on the discussion in Ref. 23 with updated γ-ray data), and unless galaxy formation occurred at an extremely efficient rate at redshifts $z \gtrsim 15$. These assumptions create

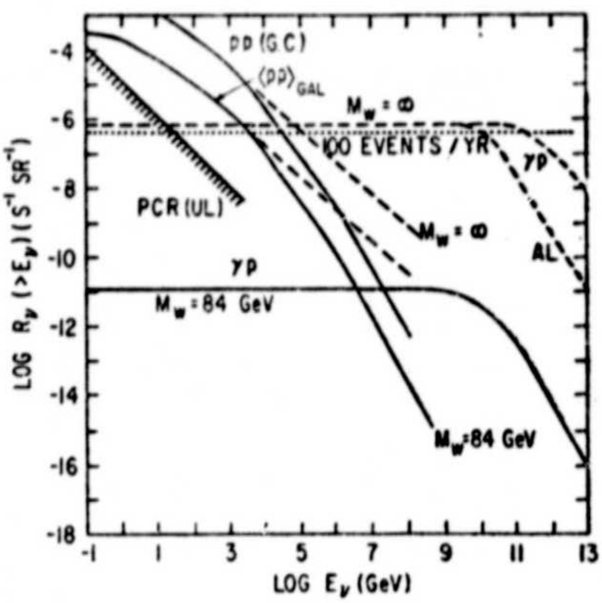


Fig. 10 - Neutrino event rates for a detector utilizing 10^{10} tons of water. For all curves except the pp(G.C.) curve, the dotted line corresponds to a <u>total</u> event rate over 4π sr. The γp curve marked AL (area limited) shows the event rate expected for an ocean detector of surface area 4 km² at energies where this rate is limited by the area of the detector rather than the cross section of the neutrino interaction.

problems of compatibility with recent x-ray observations of intergalactic gas in galaxy clusters and with radio and optical galaxy observations[52].

The remaining way of producing a high flux of neutrinos at high redshifts would be in the cores of compact astrophysical objects (quasars, Seyfert galaxies, etc.[53]). Compatibility with other observations would be maintained provided that a) the co-produced γ-radiation is absorbed in the sources, and b) the cosmic rays also do not escape the sources and produce intergalactic γ-ray emission. The difficulties with such models have already been discussed in section 6.2.

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16. Abstract

Using the most recent cosmic ray spectra up to $2x10^{20}$ eV, production spectra of high energy ν's from cosmic ray interactions with interstellar gas, and extra-galactic ultrahigh energy cosmic ray interactions with 3K universal background photons are presented and discussed. Estimates of fluxes from cosmic diffuse sources are made using the generic relationship between secondary γ's and ν's and using recent cosmic γ-ray satellite observations. Those observations in particular can provide important upper limits on cosmological ν's which are much smaller than some previous upper limits. We then give a quantitative estimate of the observability above the atmospheric background of 1-10 TeV ν's from the inner Galaxy for a DUMAND type detector. The atmospheric background fluxes used for this calculation include the contribution from charmed meson decay which can play a substantial role, particularly above 10 TeV. Event rates were estimated using a quark-parton model of the nucleon and the Weinberg-Salam model of weak interactions with $\sin^2 \theta_W = 0.2$ in calculating the νN interaction cross section. Electron ν's may be marginally observable with such a system, giving a 4-5σ signal over a four year observing time. (For ν_μ's the signal would be $\sim 2\sigma$.

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